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Effects of Light Versus Very Heavy Resisted Sprint Training on Multidirectional Speed in Semi-professional Soccer Players

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Abstract

Baena-Raya, A, Robles-Ruiz, J, Pérez-Castilla, A, Pareja-Blanco, F, and Rodríguez-Pérez, MA. Effects of light versus very heavy resisted sprint training on multidirectional speed in semi-professional soccer players. *J Strength Cond Res* 39(2): e155–e161, 2025—The purpose of this study was to evaluate the effects of an 8-week resisted linear sprint training (RST) program with 2 loading conditions (light vs. very heavy) on linear sprint (LS), curve sprint (CS), and change of direction (COD) performance in young soccer players. Thirty-eight male under-19 soccer players were assessed for 30-m LS, CS, and modified 505 COD tests. Players were randomly allocated into 3 groups: control ($n = 18$), light ($n = 10$), and very heavy RST ($n = 10$). Light and very heavy RST groups performed RST with external loads resulting in a 25 and 75% velocity loss from the player's maximal LS velocity, respectively. The control group did not perform any sprint training. Significant group × time interactions were observed for LS, CS, and COD performances ($p < 0.05$). The control group showed no performance improvement. Both RST groups showed significant improvements in LS at 10-, 20-, and 30-m ($p \leq 0.03$; effect size [ES] ≥ 0.62), whereas no significant changes were observed for the split times ($p > 0.05$). CS performance was significantly increased by the 2 RST groups ($p \leq 0.03$; ES ≥ 0.60), except for light RST on CS right side at 17-m ($p = 0.09$; ES = 0.46). Change of direction performance was only significantly enhanced by the very heavy RST group ($p \leq 0.001$; ES ≥ 0.80). No significant changes between RST groups were observed. In conclusion, using both light and very heavy RST can enhance LS and CS performance, whereas very heavy RST is recommended to optimize COD performance in young soccer players.

Key Words: linear sprint, curve sprint, change of direction, performance, acceleration, maximal velocity

Introduction

Soccer is a multidirectional team sport characterized by high-intensity activities such as linear sprints (LSs), changes of direction (CODs), and curve sprints (CSs), which are defined as the upright running portion of the sprint completed with some degree of curvature (14,22,28). Of note, CS makes up ~85% of the actions executed at maximum speed (14). The interrelationships between these speed tasks are well established. For instance, Baena-Raya et al. (4) found strong correlations (r range from −0.75 to −0.86; $p < 0.001$) between the acceleration output during both LS and CS with change of direction (COD) performance in young basketball players. Specifically, soccer players with faster LS velocities have demonstrated faster COD and CS performances but also exhibited a higher COD deficit (i.e., the additional time required to perform a COD when compared with covering the same distance in a linear trajectory) (14,16,23). Despite solid evidence linking speed-related performance variables, experimental knowledge is limited. Solleiro-Duran et al. (38) recently reported trajectory-specific adaptations from 6-week sprint training with different trajectories (LS vs. CS) on speed performance in under-16 male soccer players. Although both groups improved LS and COD performances, the LS group showed greater gains in LS, whereas only the CS group significantly enhanced CS.

The categorization of resistance training exercises helps clarify their targeted adaptations. Heavy resisted linear sprint training (RST) enhances low-velocity force application, whereas light RST improves force production at high velocities (7). In this regard, Morin et al. (29) reported enhanced short LS acceleration (i.e., first 5 m) after 8 weeks of heavy RST using 80% of body mass (BM), but a trivial negative effect (effect size [ES] = -0.16 ± 0.30) on maximum running velocity. Similarly, Cahill et al. (7) compared 4 different RST conditions: unresisted vs. the loads resulting in a velocity loss (VL) of 25, 50, and 75% from the player's LS maximal velocity. They found that the 50 and 75% VL groups achieved the greatest gains in short sprint acceleration. However, the 75% VL group also experienced a significant reduction in LS maximal velocity (7). Likewise, Rodríguez-Rosell et al. (36) observed improvements in LS performance after 8 weeks of RST with 40 and 60% of BM but not with 80% BM. These loads represented a VL of 24.0 ± 3.7%, 32.7 ± 3.3%, and 38.8 ± 4.6%, for 40, 60, and 80% of BM, respectively. Although the effectiveness of RST in enhancing sprint acceleration is well-studied, its potential impact on CS performance remains unexplored. CS results in increased ground contact times and shortened flight phases compared with LS (8,9,15), whereas RST

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leads to greater ground contact times and longer windows to apply force into the ground (6,40). Given these kinetic and kinematic similarities, it is reasonable to hypothesize that RST may also improve CS performance.

From a performance standpoint, faster COD performance is linked to greater horizontal force production and higher acceleration capacity (2,3,35). However, most previous experimental interventions on this topic have focused on vertical force-vector resistance training exercises. For example, Banyard et al. (5) found significant decreases in the 505 test ($\Delta = -4.9\%$; ES $= -1.20$) after 6 weeks of squat training at 60–85% of the 1 repetition maximum (1RM), whereas Hammami et al. (18) did not report significant reductions in COD time after an 8-week squat training at 70–90% 1RM in elite junior soccer players. Similarly, De Hoyo et al. (12) reported unclear effects on the Zig-Zag test after 8 weeks of either squat training (40–60% 1RM) or RST with 12.6% BM in under-19 elite soccer players. Regarding the potential effect of the loading used during RST on COD performance, McMorrow et al. (27) concluded that RST with 30% BM (VL of 23.1 ± 4.0%) and unresisted LS training were similarly effective at improving COD performance in senior professional soccer players. However, it is plausible that the sled load used in that RST condition was insufficient to provide an additional effect compared to the unresisted condition. Considering the potential effects of heavy RST on initial acceleration (1,25,26,29) and the role of acceleration in COD speed (2,3,35), using heavier loads during RST might further enhance COD performance in soccer players.

Therefore, the aim of the present study was to evaluate the effects of an 8-week RST program with 2 loading conditions (light vs. very heavy) on LS, CS, and COD performances in young soccer players. Based on previous literature, load-specific adaptations could be expected. Thus, very heavy RST might optimize these actions over shorter distances and lower velocities (horizontal propulsive force is required to change momentum) (25,26,29), whereas light RST might achieve greater effects over longer distances, where force is applied at higher velocities (7).

Methods

Experimental Approach to the Problem

A randomized controlled trial design was used to compare the effect of an 8-week RST program with 2 sled towing loading conditions (light vs. very heavy vs. control) on LS, CS, and COD performance in young soccer players (Figure 1). After pretesting, stratified randomization allocated players into experimental ($n = 20$) and control ($n = 18$) groups. Simple randomization further divided the experimental groups into very heavy ($n = 10$) and light ($n = 10$) RST conditions. Both experimental groups performed RST with the external loads that resulted in 25 and 75% of VL from the player's LS maximal velocity. The control group did not perform any sprint training. Before (pretest) and after (posttest) an 8-week training intervention, players were assessed for a battery of fitness tests in a single session as follows: 30 m LS, CS, and modified 505 COD. A second testing session was used to measure standing height and BM and to conduct a progressive loading sprint test to determine the player's load-velocity profile during sled towing. This test was performed to prescribe subsequent training loads. Two weeks before starting the study, the different tests were carried out once a week as part of the field workout to familiarize the players with the testing protocols. All testing and training sessions were separated by at least 48 hours of rest and were conducted on the same soccer field at the same time of day. Subjects were instructed to wear the same athletic equipment during testing sessions.

Subjects

A total of 38 male under-19 soccer players (age range: 17.5 ± 1.7 years) volunteered to participate in the present study (Table 1). All players were competing in the maximal under-19 Spanish category, with a minimum soccer experience of 10 years. None of the players exhibited any type of injury during the previous 3 months or medical contraindications that could compromise participation in the study. All players completed the intervention and complied at least 85% of all training sessions. During the intervention period, players completed their regular practices (5 technical-tactical sessions per week) and competitions (once a week). They were informed of the risks and benefits of the study and both the players, and their parents or guardians gave their written before the initiation of the study. This study was reviewed and approved by the Ethics Committee of the University of Almeria. The University of Almeria granted ethical approval to carry out the study (Ethical Application Ref: UALBIO2019/041) and all procedures were performed in accordance with the Declaration of Helsinki.

Procedures

The subjects performed a guided standardized general warm-up protocol, including 5 minutes of jogging and 5 minutes of lower-limb dynamic stretching. To complete the specific warm-up, the players performed 3 progressive LS at 75% of the player's self-perceived maximal velocity before the sprinting tests and 2 trials before the COD and CS tests. The players recovered for 3 minutes between the end of each specific warm-up and the beginning of the following test. During all measurements, subjects were encouraged to give their best performance. Each test performed is described below.

Linear Sprint Test. Players performed 2 maximal 30-m LSs separated by 2 minutes of rest. Sprint times were measured using 4 pairs of photocells (Witty, Microgate, Bolzano, Italy). Photocell timing gates were placed at 0, 10, 20, and 30 m to determine the time covered from 0 to 10 m (linear sprint time [LST10]), 0–20 m (LST20), 0–30 m (LST30), 10–20 m sprint split times (LST10–20), and 20–30 m sprint split times (LST20–30). The starting position was also standardized with lead-off foot placed 0.3 m behind the first timing gate. The fastest time was considered for subsequent analysis.

Curve Sprint Test. Players performed 2 maximal CS time right side (CSTRS) and CS time left side (CSTLS) using the art trajectory of the goalkeeper area (see Filter et al., (14) for further details). Each trial was interspersed with a 3-minute rest period. CS time was measured using 3 pairs of photocells (Witty, Microgate). Photocell timing gates were placed at 0, 8.5, and 17 m to determine the time covered from 0 to 8.5 m (CSTRS8.5 and CSTLS8.5) and 0–17 m (CSTRS17 and CSTLS17), respectively. The fastest time for each side was considered for subsequent analysis. The starting position was standardized with the lead-off foot placed 0.3 m behind the first timing gate and following the art trajectory of the goalkeeper area.

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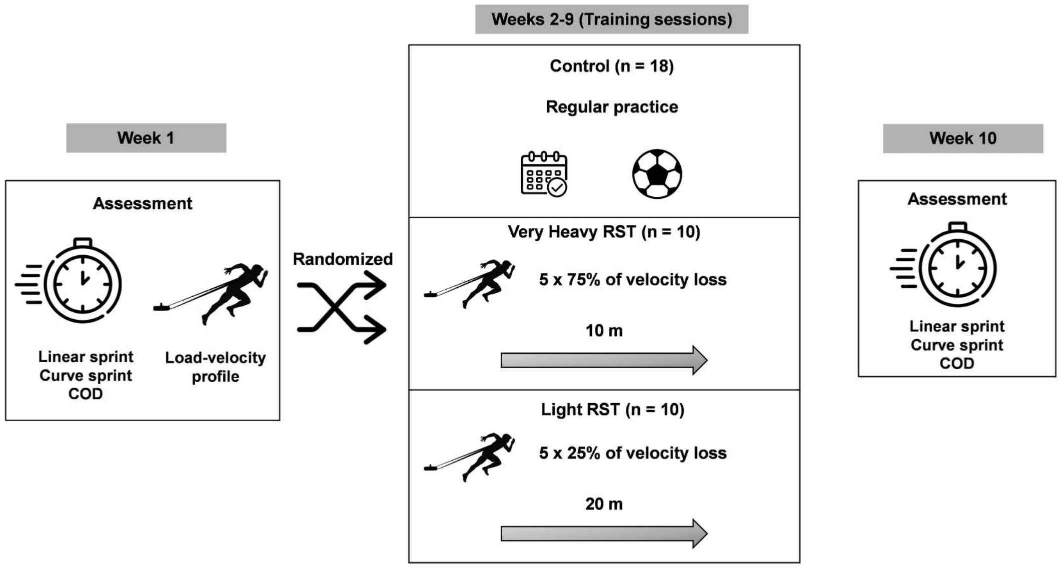

Figure 1. Descriptive characteristics of the study design. COD = changes of direction; RST = resisted linear sprint training.

Modified 505 Change of Direction Test. Players performed 2 maximal modified 505 CODs using each leg to execute the turn. Each trial was interspersed with 3 minutes of rest. Change of direction performance was measured using one pair of photocells (Witty, Microgate) and a set of cones placed 5 m from the starting position. The starting position was standardized with the lead-off foot placed 0.3 m behind the first timing gate. Players were instructed to sprint "as fast as possible" in a straight line to the turning point before changing direction 180° and sprinting back to the finish line (39). The data are presented according to the dominant (T505D) and nondominant (T505ND) sides. The fastest time for each leg was considered for further analysis.

Progressive Loading Sprint Test. Players completed 5 LSs with increasing sled towing loading: 30, 30, 20, 20, and 15 m at unresisted, 25, 50, 75, and 100% of BM, respectively, separated by 3 minutes of rest between them (10). A Stalker Acceleration Testing System II radar device (Stalker ATS II Version 5.0.2.1; Applied Concepts, Dallas, TX) was used to collect velocity-time data. The radar device was attached to a tripod 10 m behind the starting line at a height of 1 m, which corresponded approximately to the height of the subjects' center of mass. The radar device sampled the velocity-time data at 46.9 Hz. Peak averaged 2 seconds velocity (i.e., the average velocity attained and maintained for 2 seconds at maximum effort) was taken for each sled load. The data were then fit with a least-square linear regression to generate an individualized load-velocity profile for each player, outlined in previous literature (35). In these data, the unresisted sprint was included as a "zero load" condition. We substituted the velocity at which 25 and 75% VL were produced into the equation determined from the linear regression to provide the corresponding loading for these velocities (10). Previous research with a similar population has reported highly accurate linear fits on the load-velocity profile ($r^2 = 0.98 \pm 0.01$) and interindividual coefficients of variation (CV %) ranging from 3.9 to 8.8% for predicting 25 and 75% VL (10,25,26).

Table 1
Physical characteristics of soccer players.*†

	Control ($n = 18$)	Light RST ($n = 10$)	Very heavy RST ($n = 10$)
Age (y)	17.1 ± 1.5	17.6 ± 2.0	17.9 ± 1.6
Height (cm)	176.8 ± 7.2	176.3 ± 7.4	175.3 ± 8.1
Body mass (kg)	72.2 ± 6.6	72.5 ± 8.3	73.5 ± 4.7

*Control = control group; light RST = group that performed resisted linear sprint training with the external load that resulted in 25% of velocity loss from the player's maximal velocity; very heavy RST = group that performed resisted linear sprint training with the external load that resulted in 75% of velocity loss from the player's maximal velocity.
†Data are mean ± *SD*.

Training Program. The training intervention program was performed 2 times a week (total of 16 training sessions), separated by at least 48 hours of recovery (1). All training sessions were conducted on the same grass soccer field, with subjects instructed to wear the same athletic equipment during testing sessions. The training involved 5 sets of sled towing over 8 consecutive weeks, with loads resulting in 25 and 75% VL from the player's LS maximal velocity. All players were harnessed at their waist, using the 21-kg sprint sleds (DINOX, customized sled, Finland). A 3-minute rest between sets was always used. The distance covered by each RST group was different. These distances were selected from previous RST research, based on the distance required to reach the maximal velocity in each loading condition: 10 m per set for the very heavy RST and 20 m for the light RST (7,10,11,25,26,29). Before each session, subjects completed a standardized warm-up, including 5 minutes of jogging, 5 minutes of lower-limb dynamic stretching, 3 progressive LSs at 75% of the player's self-perceived maximal velocity, and 2 RST of 10 m with 50% of the specific loading condition (25% or 75% VL). A certified strength and conditioning coach supervised each sprint session, motivating players to exert maximum effort.

Statistical Analyses

Values as reported as mean and *SD*. Within-session reliability was analyzed using the intraclass correlation coefficient ($ICC_{3,1}$) and CV and interpreted according to Hopkins et al. (20). Test-retest absolute reliability was measured by the CV while relative reliability was calculated using ICC with the 1-way random effects

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model. The normality of the distribution of the variables at pretest was examined with Shapiro-Wilk test, and the homogeneity of variance across groups was verified using Levene's test. Data were analyzed using a 3 × 2 factorial analysis of covariance (ANCOVA) (with baseline values as covariate) analysis with Bonferroni's post hoc adjustments using 1 between factor (control vs. light RST vs. very heavy RST) and 1 within factor (pretest vs. posttest). The magnitude of the differences was quantified through the standardized mean differences (Cohen's *d* ES calculated as the raw mean difference divided by the pooled *SD* of the compared conditions with the corresponding 95% confidence intervals). The ES for changes between the training protocols for each performance variable was calculated as follows: (mean post-pre differences of one condition) − (mean-post-pre differences of another condition)/pooled *SD*; and the following criteria were used for interpretation: trivial (<0.20), small (0.20 to <0.60), moderate (0.60 to <1.20), large (1.20 to <2.00), and extremely large (>2.00) (21). The statistical significance was set at $p < 0.05$. All the statistical analyses were performed using the software package SPSS (version 25.0; IBM SPSS, Chicago, IL).

Results

Within-session reliability is shown in Table 2. All speed tests showed high relative (ICC ≥ 0.90) and absolute (CV < 5%) reliability before and after the sprint training.

No significant differences between groups were observed at pretest ($p \geq 0.32$). Significant "group" × "time" interactions were observed for all performance variables analyzed, except for CSTRS17, LST10–20, and LST20–30 (Table 3). Both RST groups showed significant improvements in LS at T10, T20, and T30 ($p \leq 0.03$; ES ≥ 0.62), whereas no significant changes were observed for LST10–20 and LST20–30 (both $p > 0.05$). Regarding intragroup ES, very heavy RST showed greater ES for T10 (ES = 0.96 [0.04–1.89]), whereas light RST achieved greater ES for T30 (ES = 1.26 [0.30–2.22]) (Figure 2). Likewise, both loading conditions showed significantly lower CS times for both distances and directions ($p \leq 0.05$; ES ≥ 0.60), except for light RST on CSTRS17 ($p = 0.09$; ES = 0.46). The light RST and very heavy RST groups showed significant improvements in COD performance regarding the control group ($p \leq 0.05$). However, COD performance was only significantly enhanced after the very heavy RST group in both the dominant and the nondominant legs ($p \leq 0.001$; ES ≥ 0.80). Between-groups ES is shown in Figure 3.

Discussion

This study was designed to evaluate the effect of two 8-week RST programs differing in the loading condition (light vs. very heavy) on multidirectional speed in young soccer players. The main findings indicate enhanced LS and CS performance after both loading conditions, although COD performance was only significantly increased after the very heavy RST. Furthermore, very heavy RST seems to be optimal for enhancing early acceleration (i.e., T10), whereas light RST demonstrated a more substantial ES for higher-speed phases (i.e., T30). These results support the usefulness of RST to optimize soccer players' multidirectional speed performance and highlight the importance of considering distance when determining the loading for RST.

Resisted sprint training is recommended for enhancing LS performance in soccer players (31). Our study supports this statement because both RST groups significantly improved at the different sprint distances. The selection of the RST intensity across the load-velocity spectrum can affect the resultant horizontal force, power, and velocity outputs during sprint acceleration (19,30,34). Some controversy remains regarding the optimal load for RST. Although heavier RST (e.g., ~50–75% VL) is recommended for enhancing the initial acceleration phase (0–20 m), lighter loads (e.g., ≤ 25% VL) are suggested for improving the maximal velocity phase (i.e., 20–40 m) (7). Consistent with these recommendations, we observed load-specific adaptations in the LS times because very heavy RST resulted in greater ES for T10, whereas light RST achieved greater ES for T30 (Figure 2). It has been suggested that very heavy RST can enhance acceleration by enabling higher horizontal force production during sprinting (29), whereas light RST may help athletes maintain more consistent sprint kinetics and kinematics in the higher-velocity phases of sprinting (6,33). Of note, we did not account for the players' initial sprint force-velocity profile during group allocation, which could affect their response to training at different velocities of the force-velocity spectrum (26). This factor may lead to larger within-group variations, potentially because the RST may not have targeted their specific deficits in horizontal force application.

For the first time, we have assessed the effect of an RST program on CS performance in soccer players. Although previous research highlighted the need to assess and train both linear and curvilinear actions because of their unique mechanical and technical aspects (8,9,15), this study indicates that RST on linear paths, whether with light or very heavy loads, can provide

Table 2
Within-session reliability for each speed test before and after sprint training.*

	Pre		Post	
Speed test	ICC (95% CI)	CV % (95% CI)	ICC (95% CI)	CV % (95% CI)
LST10 (s)	0.99 (0.98–0.99)	0.73 (0.61–0.90)	0.98 (0.97–0.99)	0.71 (0.60–0.88)
LST20 (s)	0.99 (0.98–0.99)	0.42 (0.35–0.51)	0.98 (0.97–0.99)	0.50 (0.41–0.61)
LST30 (s)	0.99 (0.99–1.00)	0.35 (0.29–0.43)	0.99 (0.99–1.00)	0.28 (0.24–0.35)
LST10–20 (s)	0.90 (0.83–0.94)	1.28 (1.08–1.60)	0.90 (0.84–0.94)	1.53 (1.29–1.89)
LST20–30 (s)	0.93 (0.89–0.96)	1.48 (1.24–0.83)	0.96 (0.94–0.98)	1.09 (0.91–1.35)
CSTRS8.5 (s)	0.98 (0.96–0.99)	0.92 (0.77–1.14)	0.99 (0.98–0.99)	0.75 (0.63–0.92)
CSTRS17 (s)	0.99 (0.98–0.99)	0.55 (0.47–0.69)	0.98 (0.97–0.99)	0.59 (0.49–0.73)
CSTLS8.5 (s)	0.98 (0.97–0.99)	0.80 (0.67–0.99)	0.99 (0.99–1.00)	0.71 (0.60–0.88)
CSTLS17 (s)	0.99 (0.99–1.00)	0.46 (0.39–0.57)	0.99 (0.99–1.00)	0.48 (0.40–0.60)
T505D (s)	0.99 (0.98–0.99)	0.61 (0.51–0.75)	0.98 (0.97–0.99)	0.71 (0.60–0.88)
T505ND (s)	0.98 (0.97–0.99)	0.63 (0.53–0.78)	0.99 (0.98–0.99)	0.48 (0.41–0.60)

*LST10 = linear sprint time in 10 m; LST20 = linear sprint time in 20 m; LST30 = linear sprint time in 30 m; LST10–20 = 10- to 20-m sprint split times; LST20–30 = 20- to 30-m sprint split times; CSTRS8.5 = curve sprint time right side 8.5 m; CSTRS17 = curve sprint time right side 17 m; CSTLS8.5 = curve sprint time left side 8.5 m; CSTLS17 = curve sprint time left side 17 m; T505D = test505mod dominant side; T505ND = test505mod non-dominant side; ICC = intraclass correlations coefficient; 95% CI = 95% confidence interval; CV = coefficient of variation.

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Table 3

Changes in performance variables from pre-to post-training intervention for each group.*

	Control ($n = 18$)			Light RST ($n = 10$)			Very heavy RST ($n = 10$)			ANCOVA	
Performance variables	**Pre (mean ± *SD*)**	**Post (mean ± *SD*)**	***p***	**Pre (mean ± *SD*)**	**Post (mean ± *SD*)**	***p***	**Pre (mean ± *SD*)**	**Post (mean ± *SD*)**	***p***	**Time (*p*)**	**Interaction (*p*)**
LST10 (s)	1.72 ± 0.08	1.73 ± 0.10	0.09	1.85 ± 0.09	1.78 ± 0.10†	<0.01	1.84 ± 0.09	1.77 ± 0.05†	0.03	0.14	<0.01
LST20 (s)	2.99 ± 0.13	3.01 ± 0.15	0.08	3.12 ± 0.09	3.02 ± 0.11‡	<0.01	3.10 ± 0.11	3.02 ± 0.08‡	<0.01	0.51	<0.001
LST30 (s)	4.22 ± 0.20	4.23 ± 0.19	0.49	4.35 ± 0.09	4.23 ± 0.10‡	<0.001	4.29 ± 0.15	4.20 ± 0.14‡	<0.01	0.07	<0.001
LST10–20 (s)	1.28 ± 0.05	1.29 ± 0.08	0.21	1.27 ± 0.04	1.24 ± 0.07	0.21	1.26 ± 0.04	1.25 ± 0.05	0.23	0.06	0.85
LST20–30 (s)	1.24 ± 0.08	1.22 ± 0.06	0.15	1.22 ± 0.05	1.21 ± 0.08	0.50	1.19 ± 0.05	1.18 ± 0.07	0.46	0.15	0.20
CSTRS8.5 (s)	1.54 ± 0.07	1.54 ± 0.07	0.94	1.50 ± 0.09	1.44 ± 0.11†	0.03	1.51 ± 0.15	1.42 ± 0.08‡	0.02	<0.01	<0.01
CSTRS17 (s)	2.74 ± 0.12	2.68 ± 0.12	<0.01	2.68 ± 0.11	2.63 ± 0.11	0.09	2.69 ± 0.17	2.59 ± 0.09	0.01	<0.01	0.30
CSTLS8.5 (s)	1.59 ± 0.10	1.60 ± 0.10	0.50	1.52 ± 0.09	1.43 ± 0.08‡	<0.01	1.57 ± 0.13	1.42 ± 0.08‡	<0.01	<0.01	<0.001
CSTLS17 (s)	2.71 ± 0.13	2.71 ± 0.14	0.93	2.64 ± 0.11	2.56 ± 0.10‡	0.02	2.68 ± 0.18	2.55 ± 0.10‡	0.02	<0.01	<0.001
T505D (s)	2.53 ± 0.13	2.55 ± 0.15	0.36	2.60 ± 0.14	2.53 ± 0.09†	0.43	2.65 ± 0.13	2.55 ± 0.12‡	<0.001	0.06	<0.01
T505ND (s)	2.54 ± 0.13	2.59 ± 0.13	<0.01	2.60 ± 0.09	2.54 ± 0.09‡	0.16	2.62 ± 0.08	2.53 ± 0.09‡	<0.001	0.13	<0.001

*Control = control group; light RST = group that performed resisted linear sprint training with the external load that resulted in 25% of velocity loss from the player's maximal velocity; very heavy RST = group that performed resisted linear sprint training with the external load that resulted in 75% of velocity loss from the player's maximal velocity; ANCOVA = analysis of covariance; LST10 = linear sprint time in 10 m; LST20 = linear sprint time in 20 m; LST30 = linear sprint time in 30 m; LST10–20 = 10- to 20- m sprint split times; LST20–30 = 20- to 30- m sprint split times; CSTRS8.5 = curve sprint time right side 8.5 m; CSTRS17 = curve sprint time right side 17 m; CSTLS8.5 = curve sprint time left side 8.5 m; CSTLS17 = curve sprint time left side 17 m; T505D = test505mod dominant side; T505ND = test505mod non-dominant side.

†Statistically significant differences with respect to the control group: $p < 0.05$.

‡Statistically significant differences with respect to the control group: $p < 0.01$.

significant benefits to CS performance. CS requires the generation of centripetal force over curvilinear trajectories (14,17), leading to increased ground contact time, decreased mean race velocity, and different neuromuscular activity in the outside and inside legs (15). Therefore, the kinetic and kinematic features of the sprint are trajectory-dependent (8). In that sense, RST, which allows

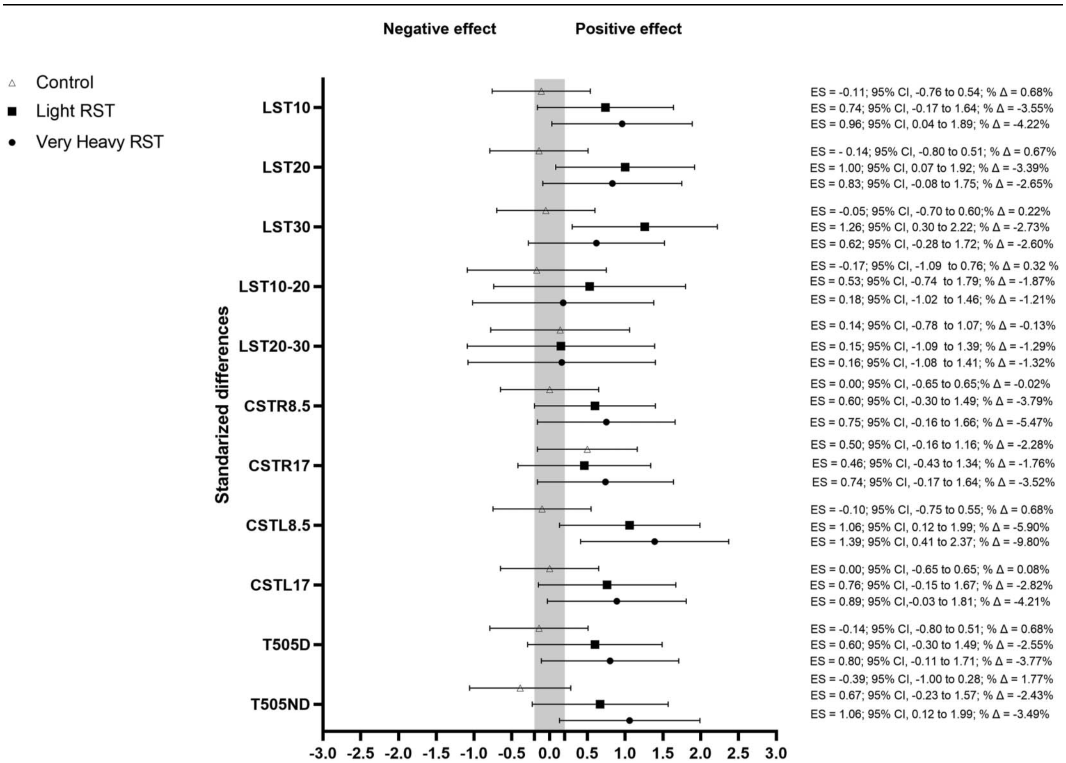

Figure 2. Standardized differences (95% CI) in all measured variables between pretest and posttest for control (open triangles), very heavy RST (filled circles), and light RST (filled squared) groups. Control: control group; light RST: group that performed resisted linear sprint training with the external load that resulted in 25% of velocity loss from the player's maximal velocity. Very heavy RST: group that performed resisted linear sprint training with the external load that resulted in 75% of velocity loss from the player's maximal velocity. Within-group ES represents Cohen's *d* ($[\text{posttest}_{mean} - \text{pretest}_{mean}]/\text{pretest}_{SD}$) with 95% CIs. %Δ represents percentage differences ($[\text{posttest}_{mean} - \text{pretest}_{mean}]/\text{pretest}_{mean} \times 100$). CI = confidence interval; RST = resisted linear sprint training; ES = effect size. LST10 = linear sprint time in 10 m; LST20 = linear sprint time in 20 m; LST30 = linear sprint time in 30 m; LST10–20 = 10- to 20-m linear sprint split times; LST20–30 = 20- to 30-m linear sprint split times; CSTRS8.5 = curve sprint time right side 8.5 m; CSTRS17 = curve sprint time right side 17 m; CSTLS8.5 = curve sprint time left side 8.5 m; CSTLS17 = curve sprint time left side 17 m; T505D = test505mod dominant side; T505ND = test505mod nondominant side.

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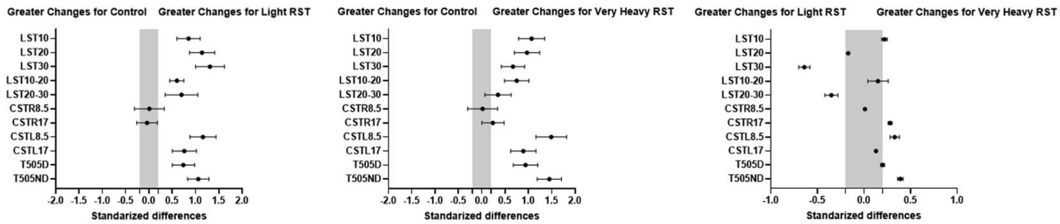

Figure 3. Standardized differences (95% CI) in all measured variables between groups. Control: control group; light RST: group that performed resisted linear sprint training with the external load that resulted in 25% of velocity loss from the player's maximal velocity; very heavy RST: group that performed resisted linear sprint training with the external load that resulted in 75% of velocity loss from the player's maximal velocity. Between-group ES represents Cohen's *d* ([9mean post-pre differences of one condition]/[mean-post-pre differences of another condition]/pooled SD). CI = confidence interval; RST = resisted linear sprint training; LST10 = linear sprint time in 10 m; LST20 = linear sprint time in 20 m; LST30 = linear sprint time in 30 m; LST10–20 = 10- to 20- m linear sprint split times; LST20–30 = 20- to 30- m linear sprint split times; CSTRS8.5 = curve sprint time right side 8.5 m; CSTRS17 = curve sprint time right side 17 m; CSTLS8.5 = curve sprint time left side 8.5 m; CSTLS17 = curve sprint time left side 17 m; T505D = test505mod dominant side; T505ND = test505mod nondominant side; ES = effect size.

athletes to maintain higher forces for longer periods (greater ground contact times than unresisted sprinting) (6) and promotes increased muscle activation during sprinting (40), may help athletes develop specific strength that leads to improved CS performance.

Change of direction requires sufficient force production to shift momentum during braking, plantar, and propulsive phases of the movement (13). Indeed, COD performance depends not only on the force a player generates but also on how efficiently that force is transmitted horizontally to the ground (2,3,13). In this context, previous literature has suggested using very heavy RST not only to maximize LS mechanics but also COD performance (2,3,35). However, to the best of our knowledge, this is the first study investigating the effects of lights vs. very heavy RST on COD performance in soccer players. Pareja-Blanco et al. (32) did not find significant performance increases in the 505 test after 8 weeks of light (12.5% BM) or heavy (80% BM) RST among physically active male sports science students. However, both RST loads were effective in increasing COD when combined with full-squat training (32). Notwithstanding, 2 potential limitations of that study could be (I) insufficient training frequency (subjects trained only once a week), and (II) the lack of trained speed athletes, limiting the generalizability of the results to subjects such as soccer players. Interestingly, as hypothesized in the present study, we observed improved COD performance after very heavy RST. Given that the T505 test involves two 5-m accelerations, it is reasonable to expect similar mechanical demands during the acceleration phase of both LS and 505 tests. Therefore, very heavy RST seems effective in enhancing performance during the early acceleration phase and short COD scenarios, where players need to exert high horizontal external force (7,11,31).

Several limitations must be considered when interpreting the results of this study. Although the sprint distances selected for each sled towing condition were based on previous research (7,10,11,26), the total training volume (sets × distance) differs between groups, potentially affecting the training adaptations. Therefore, future research should explore the effects of implementing very heavy vs. light RST with similar training volume on multidirectional speed performance. Similarly, our training design was based on a previous study by Morin et al. (30), which used a 10-week training block involving 10 sets of 20 m RST with the load that elicited the maximal power output during linear sprinting. However, because progression is a key training principle influencing individual adaptation (24), modifying the training load throughout the intervention could have influenced the training response. This aspect warrants further investigation. Of note, each player trained with the load previously prescribed to their group, with no midpoint or weekly adjustments. Although most RST evidence uses fixed loads (e.g., % BM or loads associated with specific velocity reductions) for the entire intervention, incorporating velocity feedback during sessions could help verify training intensity on a weekly basis. Moreover, the sample size was relatively small and did not include senior top-level soccer players. Given the age and playing standard differences in speed performance (37), additional research exploring senior top-level soccer players is recommended to confirm these findings.

Practical Applications

An 8-week RST program, whether with light or very heavy conditions, improved LS and CS performance to a similar extent in young soccer players. These results suggest that implementing RST on linear paths may also significantly benefit CS performance. Moreover, heavy RST seems beneficial for improving the acceleration phase in sprinting, whereas light RST may be more suitable for enhancing performance in the high-speed phases of the sprint. Importantly, only the very heavy RST group improved COD performance for both distances and directions. Given that sprint acceleration and COD share similar mechanical demands, and very heavy RST is known to improve horizontal force application during sprint acceleration, it is reasonable to suggest including very heavy RST to also enhance COD performance in soccer players. These findings highlight the importance of tailoring RST programs to specific sprint distances and trajectories because the choice of resistance can have a significant impact on sprint performance outcomes.

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